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ORIGINAL ARTICLE

Factors associated with diabesity in older women: A cross-sectional investigation

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Abstract

Objective: To investigate the factors associated with diabesity in older women.

Methods: This epidemiological study used a cross-sectional design and included 196 older women (72.70 ± 7.20 years) from Jequié, Bahia, Brazil. Diabesity was defined as having both an elevated abdominal circumference (≥88 cm) and diabetes mellitus. For the inferential analyses, we constructed crude models followed by a multiple hierarchical explanatory model, with the following levels: Level 1 (socioeconomic variables), Level 2 (behavioral aspects), and Level 3 (health conditions). Poisson regression with a robust estimator was employed, and we calculated Prevalence Ratios (PR) with 95% Confidence Intervals (CI).

Results: The prevalence of abdominal obesity, diabetes mellitus, and diabesity were 79.60%, 27.80%, and 22.40%, respectively. Women who were insufficiently active had a higher likelihood of diabesity (PR: 2.04; 95% CI: 1.22–3.41), as did those who spent more time in sedentary behavior (PR: 1.81; 95% CI: 1.04–3.16), used three or more continuous medications (PR: 2.51; 95% CI: 1.29–4.89), or reported a negative self-perception of health (PR: 2.57; 95% CI: 1.03–5.80).

Conclusion: The study identified several factors associated with diabesity in older women: insufficient physical activity, prolonged sedentary behavior, polypharmacy, and negative self-perception of health.

KEYWORDS
central adiposity, diabetes mellitus, women's health

1 | INTRODUCTION

Due to the gradual loss of ovarian function that occurs with aging, estrogen and progesterone, the primary female sex steroid hormones, experience significant declines. These changes affect various physiological systems and have health implications for women, such as excessive fat accumulation in adipose tissue, particularly in the central region of the body, leading to abdominal obesity (AO).[1,2]

As a result, AO is more prevalent in older women compared to older men,[3,4] making women more susceptible to chronic diseases like diabetes mellitus.[5] The coexistence of obesity and diabetes mellitus is termed diabesity,[6] which is recognized as a significant public health issue due to its association with increased mortality risk.[7]

Considering that diabesity is a multifactorial morbidity,[6,8] it is plausible to hypothesize that factors such as behavioral aspects and health conditions increase the likelihood of its occurrence. However, a review of the literature reveals that epidemiological research from this perspective has been conducted with both adults and older people without sex stratification,[8–10] indicating a scarcity of specific research on older women.

This gap highlights the need for epidemiological research to examine the prevalence and determinants of diabesity among older women. Such information can assist health professionals in more accurately screening for diabesity during the aging process in women. Additionally, it can support health promotion, prevention, and recovery strategies aimed at this population. Therefore, the aim of this study was to investigate the factors associated with diabesity in older women.

2 | METHODS

2.1 | Study design, location, and population

This epidemiological investigation employed a cross-sectional design and was structured according to the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology.[11] The study involved older women from the Association of Friends, Social Groups, and Open University for Older People (AFSGOUOP) in Jequié, Bahia, Brazil.[12] AFSGOUOP comprises 11 groups distributed across the main neighborhoods of the municipality, with 280 women actively participating. Established in 2001, AFSGOUOP aims to improve the quality of life for older adults by enhancing knowledge of protective laws, promoting citizenship, inclusion, participation in physical and recreational activities, and personal empowerment, all aiming for autonomy and independence. Initially created for older individuals, it now includes those aged 50 and above.

2.2 | Ethical aspects

This study involved human subjects and complied with Resolution No. 466/2012. It was approved by the Research Ethics Committee of the State University of Southwest Bahia, under CAAE No. 67839516.6.000.0055 and Opinion No. 2.073.844. All participants were informed about the study's objectives and protocols and subsequently signed the Informed Consent Form.

2.3 | Eligibility criteria

Sampling for eligibility was non-probabilistic to meet the following criteria: female participants aged 60 years or older who were members of the AFSGOUOP.[13] The exclusion criteria included presenting a cognitive deficit, assessed through the reduced and validated version of the Mini-Mental State Examination (MMSE),[14] with a cutoff score of less than 13 points,[15] or not being located in their respective group after three visits.[16]

2.4 | Data collection

Data collection was conducted in a single stage at the locations where the AFSGOUOP groups operate. Initially, a specific form was used to gather socioeconomic, behavioral, and health-related information from the participants. Subsequently, the older women were directed to a private room for anthropometric measurements and handgrip strength (HGS).[16]

2.5 | Independent variables

2.5.1 | Socioeconomic

Variables included age group (60–69, 70–79, ≥80 years); marital status (married/stable union, single/divorced, or widowed); literacy (ability to read and write a message: yes or no); family income (up to 1 minimum wage or more than 1 minimum wage); and skin color (white or non-white).[13]

2.5.2 | Behavioral

Variables included alcohol consumption in the last 3 months (did not consume or consumed at least 1 day per week); smoking status (current smoker, ex-smoker, or never smoked)[13]; and physical activity level, assessed using the International Physical Activity Questionnaire (IPAQ).[17] Women who engaged in less than 150 min per week of moderate to vigorous physical activity (PA) were considered insufficiently active.[18] Sedentary behavior (SB) was assessed using the fifth domain of the IPAQ,[17] which measures time spent sitting or reclining on a typical weekday and weekend day. The weighted average of SB was calculated as follows: (5 × min/week day) + (2 × min/weekend day)/7.[19] The cutoff for high exposure to SB was set at the 75th percentile of the weighted average (≥240 min/day).

2.5.3 | Health conditions

Variables included diagnoses of hypertension (yes or no) and osteoporosis (yes or no); occurrence of falls in the last 12 months (yes or no)[13]; polypharmacy (use of three or more continuous medications)[20]; self-perceived health (positive or negative); and dynapenia, identified by HGS values ≤ 16 kg-force.[21] Further details about the instrument and protocols used for measuring HGS can be found in Santos et al.[12]

2.6 | Dependent variable

Obesity was identified based on an abdominal circumference of 88 cm or greater. This cutoff point, recommended by the World Health Organization (WHO),[22] is used to define AO as it indicates a high level of visceral fat and, consequently, a higher cardiovascular risk in women. Abdominal circumference was measured with the participants standing, arms crossed over their shoulders, and feet together, using the umbilical scar as the reference point.[22] Measurements were taken immediately after a normal exhalation, using a flexible, inelastic anthropometric tape (Cescorf®), in triplicate. The average of these measurements was used for analysis. Diabetes mellitus was assessed with the question: "Has any doctor ever told you that you have high blood sugar, that is, that you are diabetic?" Women who had AO and responded positively to this question were classified as having diabesity.[6]

2.7 | Statistical analysis

Participant characteristics were described using absolute and relative frequencies, means and standard deviations, and response percentages for each variable analyzed. Bivariate analyses were then performed using Poisson regression with a robust estimator, which allowed for the calculation of Prevalence Ratios and their respective 95% Confidence Intervals. Variables with a *p*-value less than or equal to 20% ($p \leq 0.20$) were considered for inclusion in the multivariate analysis. This analysis employed a hierarchical model with three levels: socioeconomic aspects as the most distal level (Level 1); behavioral aspects as the intermediate level (Level 2); and health conditions as the most proximal level (Level 3)[10]—Figure 1.

Modeling commenced with the variables at the most distal level, followed by the gradual inclusion of subsequent levels. This approach ensured that the effect of each independent variable on the outcome was controlled for variables at the same level and those from preceding levels, in a hierarchical manner. Only independent

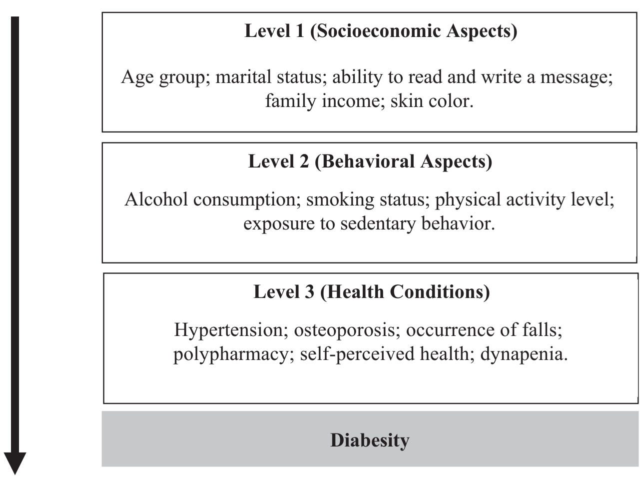

FIGURE 1 Hierarchical model used to identify factors associated with diabesity in older women.

variables that retained a *p*-value ≤ 0.20 after intra- and inter-level adjustments made up the final model. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 21 (IBM, Chicago, IL), with a significance level set at 5% ($p \leq 0.05$).

3 | RESULTS

According to information from the management of the Association of Friends, Social Groups, and Open University for Older People, 11 active groups were identified, comprising 280 middle-aged and older women.[16] Of these, 196 women constituted the study population, as illustrated in Figure 2.

Among the participants, the mean age was 72.70 ± 7.20 years. The prevalence of AO, diabetes mellitus, and diabesity were 79.60%, 27.80%, and 22.40%, respectively. Additionally, 49.50% of the participants were widowed; 30.20% exhibited insufficient physical activity level; 76.50% reported hypertension; and 52.90% were taking three or more medications. Further details about the participants' characteristics are provided in Table 1.

Table 2 presents the results of the bivariate analyses between the independent variables and diabesity. The analysis revealed that the variables marital status, skin color, physical activity level, sedentary behavior, hypertension, polypharmacy, occurrence of falls, and self-perceived health had *p*-values ≤ 0.20. Consequently, these variables were selected for inclusion in the multivariate analysis.

In the multivariate analysis, intra- and inter-level adjustments were performed using variables with a *p*-value ≤0.20 from the gross analyses. Hierarchical modeling was employed, where variables at Level 1 (socioeconomic) controlled for variables at this level, while Level 2 (behavioral) variables were controlled for by both the socioeconomic variables and other Level 2 variables. Finally, Level 3 (health conditions) variables were controlled for by themselves as well as by variables at Levels 1 and 2.

The final adjusted explanatory model identified the following independent variables as being associated with the outcome in the study population: insufficient physical activity (PR: 2.04; 95% CI: 1.22–3.41); high exposure to sedentary behavior (PR: 1.81; 95% CI: 1.04–3.16); polypharmacy (PR: 2.51; 95% CI: 1.29–4.89); and negative self-perception of health (PR: 2.57; 95% CI: 1.10–5.97)—Table 3.

4 | DISCUSSION

This is the first epidemiological study to investigate the factors associated with diabesity in older Brazilian women. The main findings revealed that insufficient physical activity, high exposure to sedentary behavior, polypharmacy, and negative self-perception of health were associated with the outcome. Therefore, these results are significant findings that may help fill gaps regarding the multiple factors that independently increase the likelihood of this outcome in older women.

Although there has been little research into diabesity in older women, there are studies in the literature on adults and the older

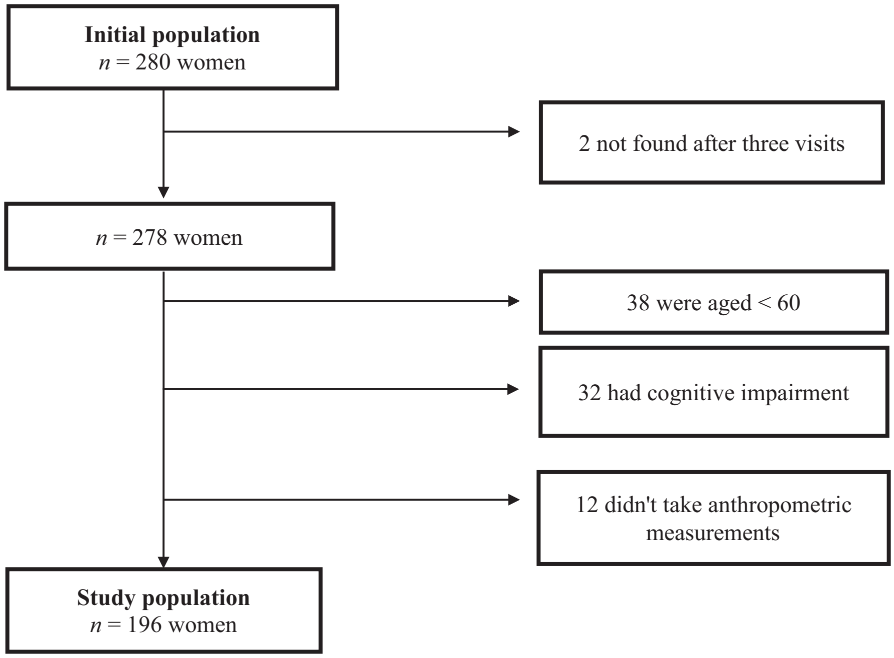

FIGURE 2 Diagram of decisions in the process of selecting the women who took part in the study.

people.[7,8,23] The results of these studies differ from those of our research, particularly in terms of prevalence. In our study, the observed prevalence of diabesity was approximately 22.40%. In contrast, the National Health and Nutrition Examination Surveys reported a diabesity prevalence of 11% among older men and women (65 years and older) in the United States of America.[23] Similarly, the Mexican Health and Aging Study found a diabesity prevalence of 6.90% among adults and older individuals (50 years and older) in Mexico.[7]

These disparities are likely related to the anthropometric indicators used to define obesity. The studies mentioned[7,23] defined obesity using body mass index, an indicator that reflects the distribution of body mass relative to stature and is used to assess general obesity. In this study, we used abdominal circumference, which reflects the distribution of visceral fat and is associated with greater health risks.[22]

Regarding the associations found in this study, literature provides hypothetical explanations for the association between polypharmacy and the outcome studied. For instance, Córralo et al.[24] observed in a cross-sectional study involving 127 older individuals (67.71% women) from Frederico Westphalen, Rio Grande do Sul, Brazil, that participants with diabetes mellitus used an average of 5.80 medications, higher than the general average of 3.50 medications among older adults.[25] Additionally, Córralo et al.[24] found a high prevalence of polypharmacy (85.80%) among older individuals with diabetes mellitus, attributed to both the disease and associated comorbidities.

Considering that diabesity is a phenotype constituted by two chronic morbidities[6–10] and the high prevalence of hypertension among the participants in the present study, there is a high burden of comorbidities that possibly explains the higher likelihood of diabesity among older women who used three or more medications.[8] Finally, it is worth noting the characteristics of the study population, which consisted only of older women, as they appear to be more prone to polypharmacy. Among the reasons for this are the higher life expectancy and greater awareness of self-care and treatment of comorbidities.[26]

With regard to self-perceived health, a cross-sectional study conducted with 676 older individuals (54.60% women) from Coxilha and Estação, Rio Grande do Sul, Brazil,[27] showed that poor/very poor self-perception of health was associated with a high burden of morbidities. In the study by Sinha, Puri, and Pati,[8] conducted in India with 59,073 participants (age ≥45 years; 49.95% older individuals), the authors reached a similar conclusion, finding that adults and older individuals with diabesity considered themselves less satisfied with their health compared to those with obesity or diabetes mellitus separately. In this sense, it is plausible to infer that the association of negative health perception identified in the present study is due to the possible implications that obesity and diabetes can have on the health of the older people. Among them are impacts on quality of life, deficits in self-care, and a higher degree of dependence on daily living activities.[27]

Regarding PA, insufficient levels tend to result in a decline in muscle mass, mitochondrial volume, and oxidative capacity, as well as changes in the expression of genes involved in mitochondrial function. These changes contribute to decreased insulin sensitivity and culminate in hyperinsulinemia, which is the body's pathophysiological adaptation to maintain acceptable glucose levels.[28] This is supported by the systematic review conducted by Sirico et al.,[29] which found that concentrations of adiponectins and adipokines involved in energy regulation were higher in individuals who engaged in regular physical activity compared to those who were inactive.

Therefore, it is evident that sufficient physical activity can reduce leptin levels and insulin resistance, serving as a preventive factor for diabetes mellitus.[30] In addition, regular physical activity improves the lipid profile, as increased adiponectin levels reflect

TABLE 1 Descriptive analysis of the socioeconomic, behavioral, and health-related characteristics of the study participants.

Variables	% response	*n*	%
Age group	100.00		
60–69 years		59	30.10
70–79 years		103	52.60
≥80 years		34	17.30
Marital status	99.00		
Married/stable union		59	30.40
Single/divorced		39	20.10
Widowed		96	49.50
Read and write a message	99.00		
Yes		154	79.40
No		40	20.60
Family income	96.90		
>1 minimum wage		127	66.80
≤1 minimum wage		63	33.20
Skin color	99.50		
White		50	25.60
Non-White		145	74.40
Physical activity level	92.90		
Sufficient		127	69.80
Insufficient		55	30.20
High SB	97.40		
No		151	79.10
Yes		40	20.90
Smoking status	99.00		
Never smoked		141	72.70
Ex-smoker		48	24.70
Smoker		05	2.60
Alcohol consumption	99.50		
Did not consume		144	73.80
≥1 day/week		51	26.20
Hypertension	100.00		
No		46	23.50
Yes		150	76.50
Abdominal obesity	100.00		
No		40	20.40
Yes		156	79.60
Diabetes *mellitus*	100.00		
No		140	72.20
Yes		54	27.80
Diabesity	100.00		
No		152	77.60
Yes		44	22.40
Osteoporosis	98.00		
No		130	67.70
Yes		62	32.30
Polypharmacy	88.80		
No		82	47.10
Yes		92	52.90
Dynapenia	100.00		
No		171	87.20
Yes		25	12.80
Occurrence of falls	99.00		
No		142	72.40
Yes		54	27.60
Self-perceived health	100.00		
Positive		68	34.70
Negative		128	65.30

Abbreviations: %, percentage; *n*, number of participants; SB, sedentary behavior.

reduced adiposity and a shift in energy metabolism toward fatty acid consumption. This is due to the modulation of enzymes linked to oxidative metabolism. In contrast, insufficient physical activity can have deleterious effects on the body, predisposing individuals to diabesity.[28]

Concerning SB, prolonged inactivity is associated with reduced insulin sensitivity, which appears to be accompanied by a decrease in the content of GLUT-4 protein, hexokinase II, protein kinase B (Akt) 1, and Akt2 in skeletal muscle, as well as a decrease in insulin-stimulated glycogen synthase (GS) activity. These findings suggest that decreased glucose transport and reduced non-oxidative glucose metabolism in skeletal muscle contribute to altered carbohydrate metabolism, potentially favoring the development of diabetes mellitus. This is evidenced by changes in peripheral insulin sensitivity during prolonged sedentary periods.[31]

In terms of obesity, a systematic review by Pinto et al.[30] evidenced that just 1 day of sitting can reduce energy expenditure without affecting appetite in adults, which may promote lipid accumulation. Furthermore, the low muscular stimulation associated with sedentary activities generates metabolic changes that redirect glucose-derived energy to the liver, where it is converted into fatty acids and stored in adipose tissue, particularly in the abdominal region.[31]

SB is defined by prolonged periods dedicated to low-energy expenditure activities, such as sitting, reclining, or lying down during wakefulness.[32] The literature review conducted by Pinto et al.[30] demonstrated that sedentary behavior is associated with physiological changes that contribute to the development of diabesity. Therefore, it is recommended that older individuals reduce sedentary time and/or replace such inactive periods with physical activities of any intensity in their routines.[18]

In view of the above, it is pertinent to highlight that insufficient physical activity and high exposure to SB are modifiable health risk behaviors. Therefore, sufficient physical activity and low exposure

TABLE 2 Prevalence of diabesity according to independent variables in the study population.

Variables	Prevalence (%)	Gross PR (95% CI)	*p*-value
Age group			
60–69 years	23.70	1	0.772
70–79 years	23.30	0.98 (0.55–1.74)	
≥80 years	17.60	0.74 (0,31–1.75)	
Marital status			
Married/stable union	24.50	1	**0.173**
Single/divorced	10.30	0.40 (0.14–1.12)	
Widowed	26.00	1.02 (0.59–1.77)	
Read and write a message			
Yes	20.80	1	0.352
No	27.50	1.32 (0.73–2.38)	
Family income			
>1 minimum wage	20.50	1	0.438
≤1 minimum wage	25.40	1.24 (0.72–2.13)	
Skin color			
White	14.00	1	**0.112**
Non-White	25.00	1.82 (0.86–3.82)	
Physical activity level			
Sufficient	17.30	1	**0.010**
Insufficient	34.50	1.99 (1.17–3.37)	
High SB			
No	19.90	1	**0.079**
Yes	32.50	1.63 (0.94–2.83)	
Smoking status			
Never smoked	25.50	1	0.328
Ex-smoker	14.60	0.57 (0.27–1.19)	
Smoker	20.00	0.78 (0.13–4.62)	
Alcohol consumption			
Did not consume	22.90	1	0.844
≥1 day/week	21.60	0.94 (0.51–1.72)	
Hypertension			
No	6.50	1	**0.013**
Yes	27.30	4.19 (1.36–12.90)	
Osteoporosis			
No	19.20	1	
Yes	30.60	1.59 (0.95–2.66)	
Polypharmacy			
No	12.20	1	**0.002**
Yes	33.70	2.76 (1.44–5.28)	
Dynapenia			
No	20.50	1	
Yes	36.00	1.76 (0.96–3.20)	
Occurrence of falls			
No	19.00	1	**0.040**
Yes	32.70	1.72 (1.02–2.88)	
Self-perceived health			
Positive	7.40	1	**0.002**
Negative	30.50	4.14 (1.71–10.02)	

Note: Values in bold indicate $p \leq 0.20$.

Abbreviations: %, percentage; CI, confidence interval; PR, prevalence ratio; SB, sedentary behavior.

TABLE 3 Final hierarchical model of the association between independent variables and diabesity in the study population.

Level	Variables	Adjusted PR (95% CI)	*p*-value
1	Marital status		
	Married/stable union	1	0.199
	Single/divorced	0.41 (0.15–1.15)	
	Widowed	1.01 (0.58–1.74)	
	Skin color		
	White	1	0.137
	Non-white	1.75 (0.83–3.66)	
2	Physical activity level		
	Sufficient	1	**0.007**
	Insufficient	2.04 (1.22–3.41)	
	High SB		
	No	1	**0.035**
	Yes	1.81 (1.04–3.16)	
3	Polypharmacy		
	No	1	**0.007**
	Yes	2.51 (1.29–4.89)	
	Occurrence of falls		
	No	1	0.070
	Yes	1.60 (0.96–2.66)	
	Self-perceived health		
	Positive	1	**0.028**
	Negative	2.57 (1.10–5.97)	

Note: Values in bold indicate $p \leq 0.05$.

Abbreviations: %, percentage; CI, confidence interval; PR, prevalence ratio; SB, sedentary behavior.

to SB can mitigate the likelihood of chronic diseases, such as obesity and diabetes mellitus, and/or serve as an auxiliary therapy for the treatment of these morbidities.[6,18] In this regard, the WHO recommends an active lifestyle for older individuals, including moderate-intensity activities (150 to 300 min) and/or vigorous-intensity activities (75–150 min). The WHO also emphasizes the importance of incorporating muscle-strengthening exercises and activities aimed at functional balance and strength training at least 2–3 days per week, as these factors are directly associated with the quality of life in older adults.[18]

Diet plays a fundamental role in the non-pharmacological treatment of diabesity. Kapoor et al.[33] describe an integrated approach to dietary guidelines aimed at optimizing glycemic control and promoting healthy weight loss in individuals with diabetes mellitus and obesity. This approach emphasizes a balanced and varied diet that includes fiber-rich foods such as whole grains, legumes, fruits, and vegetables, which are known for their role in glycemic control and promoting satiety. The inclusion of lean proteins is essential for maintaining muscle mass, while moderation in fat consumption, particularly unsaturated fats from sources like nuts, seeds, avocados, and olive oil, supports cardiovascular health and weight control. Portion control is also emphasized as a key strategy for regulating caloric intake and promoting weight loss. Regular monitoring of blood glucose levels and the appropriate distribution of carbohydrates throughout the day are recommended practices to avoid extreme fluctuations in glucose levels. These comprehensive nutritional recommendations aim not only to control symptoms but also to promote healthy and sustainable eating habits, thereby improving quality of life and reducing the risk of complications associated with diabesity.

This study has some limitations. Self-reported diagnoses of diabetes mellitus and hypertension may not always reflect the actual prevalence of these conditions, as they can manifest silently without severe initial symptoms, potentially leading older individuals to avoid seeking medical care. This may influence the observed prevalence rates. Additionally, the indirect measurement of physical activity and sedentary behavior might result in over- or underestimation of these variables. However, the use of the MMSE as an exclusion criterion for older women with cognitive impairment is highlighted, aiming to minimize the impact of memory bias in these situations.

A notable strength of this study is its pioneering perspective in identifying factors independently associated with diabesity in older women. The use of a multiple model to control for potential confounders enhances the reliability of the findings. It is hoped that these results will assist health professionals and policymakers in developing strategies and actions within the context of primary health care to more accurately screen and manage diabesity in older women.

5 | CONCLUSION

The evidence gathered corroborated the initially proposed hypothesis, as it showed that insufficient physical activity level, high exposure to sedentary behavior, polypharmacy, and negative self-perception of health were the factors associated with diabesity in the older women participating in the present study.

AUTHOR CONTRIBUTIONS

Brum KKM, dos Santos L, Godinho GA, Carneiro JAO, Brito TA, Fernandes MH, da Silva Coqueiro R, and Miranda CGM contributed to the conception and design of the project, writing, and critical review of the manuscript. Additionally, dos Santos L performed the data analysis and interpretation. All authors declare no conflicts of interest and have approved the final version of the manuscript. They are also responsible for all aspects of the work, including ensuring its accuracy and integrity.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

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